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MEASUREMENT OF RADIATION DOSES ON THE SECOND, FOURTH AND FIFTH SPACESHIP-SATELLITES

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The orbits of the second, fourth and fifth spaceships-satellites passed at a distance of 180-340 km from the surface of the earth. This region is situated below the Earth's radiation belts, and it may be anticipated that the primary cosmic radiation (PCR), and that of solar flares are the sources of penetrating radiation.

Protons (flux of about 2 cm^{-2} sec^{-1}), alfa-particles (about 0.3 cm^{-2} sec^{-1}) and heavier nuclei (about 0.03 cm^{-2} sec^{-1}) enter into the composition of the PCR. Basing ourselves on the data of [1] concerning the average value for PCR of linear energy losses as being 3.5 MeV cm^2 g^{-1}, the primary cosmic radiation dose may be determined as 13 mrad 24 hrs^{-1}. A more detailed computation, taking into account the contribution of various components, leads to the figure of 14 mrad 24 hrs^{-1}. (see ref.[2]). Near the Earth and its shadow the PCR dose decreases by about two times, i.e. the daily (24 hr) dose must be of the order of 6 – 7 mrad during the orbiting of spaceship-satellites.

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* Izmereniye doz radiatsii na vtorom, chtvertom i pyatom kosmicheskikh korablyakh-sputnikakh.

The penetrating radiation emitted during solar flares consists of proton fluxes with energy of the order of 100 MeV. It creates during major flares doses of 30 to 100 rad per flare, whose duration may reach 24 hours [3, 4]. However, such flares occur once or twice a year at the most. The probability of proton flux occurrence from weaker flares and the radiation doses then appearing has been little studied.

Thus, during brief flights of living beings at 180 — 340 km above the earth the radiation doses will be insignificant, of the order of 6 — 7 mrad$\cdot$24 hrs^{-1}. A lengthy stay at such altitudes entails the possibility of increase of the effects of radiation to dangerous values. The above-said justifies the necessaity of conducting measurements of radiation doses during the flights of spacecrafts, so as to estimate that danger.

On the basis of ~~known data on the possible composition of radiation and its doses at indicated orbits~~, sets of autonomous dosimetric pickups (СДП), including luminescent dosimeters (ИЛК) [5, 6] with a $2\cdot10^{-3}$ — $1\cdot10^{3}$ rad. range and ИФКН dosimeters [7, 8] with a $2\cdot10^{-3}$ — $1\cdot10^{-1}$ ber range to detect slow neutrons near test animals, were ~~utilized~~ for the detection of integral radiation doses.

For the analysis of radiation composition the dosimeters were equipped with various filters. A filter made of 0.75 mm lead shielding half of the photodosimeter field served to compensate their "course with the hardness" (i.e. dependence of sensitivity on energy) for the electromagnetic radiation in the 50 keV to 3 MeV energy range. The same assignment was carried out by 1.3 mm lead-filters installed in certain ИЛК dosimeters.

Other ИЛК dosimeters had no complementary filters, or were shielded by a 3.2 mm aluminum layer, equivalent in its

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capability to the 1.3 mm lead layer for protons with energies from 5 to 300 MeV, and for electrons with 0.025 to 1 MeV energies.

In order to reduce background readings, pellicular dosimeters were loaded prior to flight with a fresh film, and the ИЛК dosimeters were throughly warmed prior to launching so as to eliminate readings conditioned by the background. To determine the level of background radiation at the Earth, control dosimeters were also prepared. Upon spaceship's return from flight the pellicular dosimeters were revealed simultaneously with the films exposed by gamma-radiation of Co^{60}, so as to plot the blackening curve, and with control films having remained on the ground during the flight. The ИЛК dosimeters' readings were compared with the results of calibration of each of them by the gamma-radiation of the Co^{60} source (calibrations prior and after the flight coincided).

The preliminary results of dosimeter irradiation by protons with energies from 100 to 60o MeV on a synchrocyclotron ОИЯИ allow to establish that dosimeter readings coincide for an equal tissue dose at their irradiation by either protons or gamma-rays.

The dosimetric packages СДП were disposed aboard the spacecraft in the immediate vicinity with the animals, as well as outside the cabin with animals. The dose induced by the background radiation for the period from the moment of preliminary heating (ИЛК) to launching, and from the moment of landing to measurement was deducted from the dosimeter readings. The average reading of the control ИЛК dosimeters constituted near 0.5 - 0.6 mrad 24 hours^{-1}. As to the pellicular dosimeters, the background readings were zero.

The results of radiation dose measurements by the ИЛК method are compiled in the Table next page. Data according to photodosimeters are omitted, inasmuch as the integral radiation doses resulted below the sensitivity threshold of the method — 0.2 rad for the photodosimeters and $2 \cdot 10^{-3}$ ber — for ИФКН.

TABLE

RADIATION DOSES INSIDE THE SPACESHIP-SATELLITE

(in mrad)

Experiment	K dosimeters' readings (background deducted)		
	without filter	with 3.2 mm Al	with 1.3 mm Pb
2nd Spaceship-satellite Flight duration — 25 hrs	13 12 14	12 11 10*	6 7.5 10**
Average	13	11	8
4th spaceship-satellite Flight duration 1.5 hrs.	7.4 5.5 — 2.1 — 2.2 — 4.6	4.3 0.4 — 5:5 — 0.9	— 1.5 7.9 0/9 — 3.3 — 2.6
Average	0.8	— 0.4	0.3
5th Spaceship-satellite Flight duration 1.5 hrs.	0.6 1.9 — 1.1 0.6 — 0.7 — 1.0	— 0.6 3.9 3.9 1.9 — 1.3	3.2 2.5 — 0.5 — 1.8 — 0.1 — 2.2
Average	0.05	2.1	0.2

* Filter's thickness 3 mm Al; ** Filter's thickness 1 mm Pb.

As may be seen from the Table, reliable data were only obtained on the 2nd spaceship-satellite. Data of the 4th and 5th spacecrafts do not contradict the first ones, to say the least. The measured quantities correspond to radiation doses of 6 — 10 mrad 24 hrs^{-1}, which agrees well with the computed doses of PCR. The obtained quantities allow the conclusion that solar flare emission did not exert any effect on the inside arrangements of the cabin during the flights of the fourth and fifth spaceships-satellites.

However, since the readings obtained by the dosimeters of the 2nd spaceship were greater with aluminum filters than with those equipped with the compensating filters made of lead, a conclusion may be derived, that aside from PCR, there was some brehmstrahlung in the registered radiation, likely caused by the 2nd spaceship's skirting the Earth's outer radiation belt. The effective quantum energy of this radiation is in the neighborhood of 100 keV, ~~as~~ is evident from the small difference between the readings of aluminum-equipped dosimeters and those without filters, and also by the coincidence of the results of measurements by dosimeters with compensating lead filters and the computed PCR doses.

Were brehmstrahlung harder, the readings by dosimeters with filters of aluminum and lead sould be close, inasmuch as in the energy region above 300 — 400 keV "the course with hardness" of ИЛК dosimeters is not great. On the other hand, if the brehmstrahlung were softer, the difference in dosimeter readings without filters and with aluminum filters would be greater.

Therefore, the setting of СДП, applied on spaceships, allowed a direct measurement of radiation doses accumulated at flights in orbits in the 180 — 340 km altitude range. The measured radiation doses of 6 — 10 mrad 24 hrs^{-1} agree well with the results of analysis of PCR doses and is evidence of the fact, that the radiation conditions was favorable during the flight of spaceships-satellites, and was not complicated by solar flare emission. The occurrence of brehmstrahlung during the flifgt of the 2nd spaceship is well established, this being due, as siad earlier, to spaceship hitting the limits of Earth's radiation belts. Brehmstrahlung doses did not lead to a substantial variation of the radiation conditions.

Taking into account the radiation hazards of solar flares and the possible variations in the position of lower boundaries of the radiation belts, it is necessary to pursue the study of radiation conditions inside spaceships during the subsequent launchings. This would permit the study of the frequency of significant increases of radiation doses due to solar flares, and to define the limits of dose variation as a consequence of spaceships' skirting the Earth's radiation belts.

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